

# Antennas

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A good antenna works

A bad antenna is a waste of time & money

Antenna systems can be very inexpensive and simple

They can also be very, very expensive





# Antenna Considerations

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- The space available for an antenna
- The proximity to neighbours
- The operating frequencies you will use
- The output power
- Money

# Antenna Types

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## High Frequency

1.6 - 30 Mhz + 50 Mhz

160 - 6 metres

An antenna's size/length depends on the frequency

It's functionality largely depends on the height above ground, as well as the polarity and it's configuration



# Some Math

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Velocity of propagation            300,000,000 m/sec

For 1 wavelength, above 30 MHz

$$\text{Frequency (f)} = 300 / \text{wavelength}$$

$$\text{Wavelength } (\lambda) = 300 / \text{frequency}$$

Frequency measured in megahertz

Wavelength measured in meters

Above 30 MHz,  $\lambda = 300/f$  metres or  $984/f$  feet

For a half wave  $\lambda = 150/f$  metres or  $492/f$  feet

Below 30 MHz  $\lambda = 286/f$  metres or  $936/f$  feet (including the velocity factor of 0.95)

For a half wave  $\lambda = 143/f$  metres or  $468/f$  feet

The length of a half wave dipole for 3.65 MHz

The length of a half wave dipole for 3.65 MHz

$$L = 143/f = 143/3.65 = 39.18 \text{ metres}$$

**The higher the frequency the shorter the antenna**

**The lower the frequency the longer the antenna**

# Types of Antennas

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## Simple wire

- Dipole
- Folded dipole
- Trap dipole
- Offset or Windom antenna
- Phased dipoles
- Vertical or horizontal (both)
- Beverage wave antenna

# Types of Antennas

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- Metal
- Vertical
- Yagi
- Trap Yagi
- Phased arrays
- Loops
- Vertical or Horizontal
- Horns for super ultra high frequencies
- Mobile antennas

# Antenna Polarization

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- Vertical or horizontal

- Electrical vs Magnetic radiation

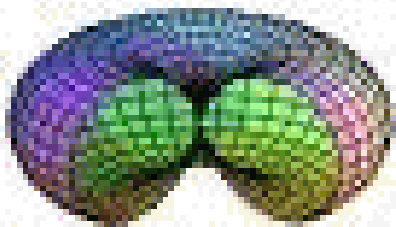
ELECTRICAL FIELD DETERMINES POLARIZATION

- Vertically polarized waves travel @  $90^\circ$  to the earth's surface
- Horizontally polarized waves travel parallel to the earth's surface
- Usually wire antennas are horizontal but an inverted 'V' dipole has a vertical component
- Yagi type antennas can be either vertical or horizontal  
Circular antennas can be both
- Usually, horizontally polarized antennas receive less electrical noise.

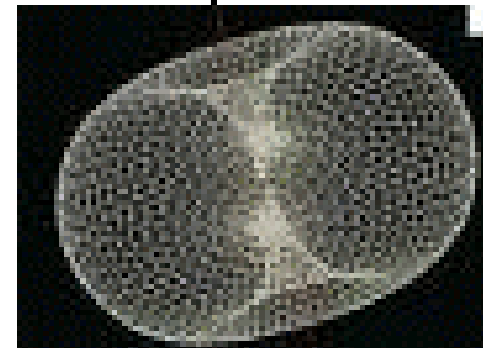
# Isotropic Antenna

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- The isotropic antenna is a hypothetical point source.
- It does not exist in reality but is considered as an important starting point considering different
- antennas from the theoretical to the practical
- The pattern is a Cardioid - a donut shape or a sphere



**Dipole Radiation  
Pattern**



# Polarization - Practical

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Antennas radiating a vertical polarization are best received by an antenna of like polarization

Cross polarization reduces reception by as much as 30 db

Refracted or reflected DX signals probably have both polarizations

Designing antenna polarization usually depends on the frequency being used - at 70 cm in the UHF band the elements are very short so either polarization is possible.

Repeaters are vertically polarized – so base stations will have the same polarity.

# Resonance

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Antenna length depends on the frequency

The lower the frequency the longer the antenna elements

Examples		1 wavelength	½ wave
80 meters	3.750 Mhz	262	131 ft
40	7.055 Mhz	139	69.7 ft
10	28.5 Mhz	34.3	17.2 ft
6	52 Mhz	19	9.46 ft
2	145 Mhz	6.8	3.4 ft
2200 meters	136 kilohertz	7236	3618 ft

# Isotropic Source

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## *Polarization by Element Orientation*

Page 48 / 9

An isotropic antenna is a: **hypothetical point source**

What is the antenna radiation pattern for an isotropic radiator? **A sphere**

Polarization of an antenna is determined by: **the electric field**

What does horizontal wave polarization mean? **The electric lines of force of a radio wave are parallel to the earth's surface**

What does vertical wave polarization mean? **The electric lines of force of a radio wave are perpendicular to the earth's surface**

# Polarization by Element Orientation

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What electromagnetic wave polarization does a Yagi antenna have when its elements are parallel to the earth's surface? **Horizontal**

What electromagnetic wave polarization does a half-wavelength antenna have when it is perpendicular to the earth's surface? **Vertical**

VHF signals from a mobile station using a vertical whip antenna will normally be best received using a: **vertical ground-plane antenna**

A dipole antenna will emit a vertically polarized wave if it is: **Parallel with the ground mounted vertically**

If an electromagnetic wave leaves an antenna vertically polarized, it will arrive at the receiving antenna, by ground wave: **vertically polarized**

Compared with a horizontal antenna, a vertical antenna will receive a vertically polarized radio wave: **at greater strength**

# Wavelength vs Physical Length

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The speed of a radio wave: **is the same as the speed of light**

The velocity of propagation of radio frequency energy in free space is: **300 000 kilometres per second**

If an antenna is made longer, what happens to its resonant frequency? **It decreases – becomes lower.**

If an antenna is made shorter, what happens to its resonant frequency? **It increases – becomes higher**

The resonant frequency of an antenna may be increased by: **shortening the radiating element**

# Wavelength vs Physical Length

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To lower the resonant frequency of an antenna, the operator should: **lengthen it**

Adding a series inductance to an antenna would:  
**decrease (lower) the resonant frequency**

# Wavelength vs Physical Length

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- The wavelength for a frequency of 25 MHz is:  
**12 metres (39.4 ft)**
- The wavelength corresponding to a frequency of 2 MHz is:  
**150 m (492 ft)**
- At the end of suspended antenna wire, insulators are used. These act to: **limit the electrical length of the antenna**
- One solution to multi-band operation with a shortened radiator is the "trap dipole" or trap vertical. These "traps" are actually: **a coil and capacitor in parallel**

# Gain, Directivity, etc.

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- What is meant by antenna gain? **The numerical ratio relating the radiated signal strength of an antenna to that of another antenna**
  - The gain of an antenna, especially on VHF and above, is quoted in dBi. The "i" in this expression stands for: **isotropic**
  - Approximately how much gain does a half-wave dipole have over an isotropic radiator? **2.1 dB**
  - What is a parasitic beam antenna? **An antenna where some elements obtain their radio energy by induction or radiation from a driven element**
  - If a slightly shorter parasitic element is placed 0.1 wavelength away from an HF dipole antenna, what effect will this have on the antenna's radiation pattern? **A major lobe will develop in the horizontal plane, toward the parasitic element**
  - If a slightly longer parasitic element is placed 0.1 wavelength away from an HF dipole antenna, what effect will this have on the antenna's radiation pattern? **A major lobe will develop in the horizontal plane, away from the parasitic element, toward the dipole**

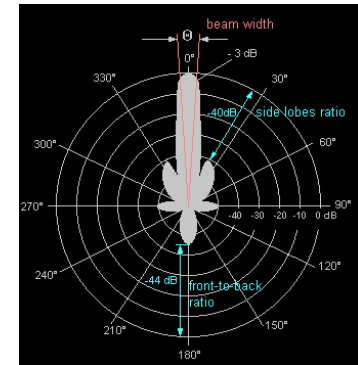
# Gain, Directivity, etc.

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- In free space, what is the radiation characteristic of a half-wave dipole?

**Minimum radiation from the ends, maximum broadside**

- The front-to-back ratio of a beam antenna is: **the ratio of the maximum forward power in the major lobe to the maximum backward power radiation**



- The property of an antenna, which defines the range of frequencies to which it will respond, is called its: **bandwidth**
- What is meant by antenna bandwidth? **The frequency range over which the antenna may be expected to perform well**
- How can the bandwidth of a parasitic beam antenna be increased? **Use larger diameter elements**

# Vertical Antennae

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- To calculate the length in metres (feet) of a quarter wave vertical antenna you would : **Divide 71.5 (234) by the antenna's operating frequency (in MHz)**
  - If you made a quarter-wavelength vertical antenna for 21.125 MHz, how long would it be? **3.6 metres (11.8 ft)**
  - If you made a half-wavelength vertical antenna for 223 MHz, how long would it be? **64 cm (25.2 in)**
  - If a magnetic-base whip antenna is placed on the roof of a car, in what direction does it send out radio energy? **It goes out equally well in all horizontal directions**
  - What is an advantage of downward sloping radials on a ground plane antenna? **It brings the feed point impedance closer to 50 ohms**

# Vertical Antennae

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What happens to the feed point impedance of a ground-plane antenna when its radials are changed from horizontal to downward-sloping? **It increases**

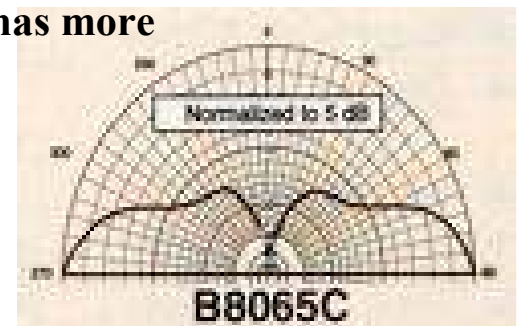
Which of the following transmission lines will give the best match to the base of a quarter-wave ground-plane antenna? **50 ohms coaxial cable**

The main characteristic of a vertical antenna is that it will: **receive signals equally well from all compass points around it**

Why is a loading coil often used with an HF mobile vertical antenna? **To tune out capacitive reactance**

What is the main reason why so many VHF base and mobile antennas are  $5/8$  of a wavelength? **The angle of radiation is low**

Why is a  $5/8$ -wavelength vertical antenna better than a  $1/4$ -wavelength vertical antenna for VHF or UHF mobile operations? **A  $5/8$ -wavelength antenna has more gain**



# Yagi Antennae

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How many directly driven elements do most Yagi antennas have? **One**

Approximately how long is the driven element of a Yagi antenna for 14.0 MHz? **10.21 metres (33 feet and 6 inches)**

Approximately how long is the director element of a Yagi antenna for 21.1 MHz? **6.4 metres (21 feet)**

Approximately how long is the reflector element of a Yagi antenna for 28.1 MHz? **5.33 metres (17.5 feet long)**

The spacing between the elements on a three-element Yagi antenna, representing the best overall choice, is : **0.2 of a wavelength.**

What is one effect of increasing the boom length and adding directors to a Yagi antenna? **Gain increases**

What are some advantages of a Yagi with wide element spacing? **High gain, less critical tuning and wider bandwidth**

# Yagi Antennae

Con't

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What are some advantages of a Yagi with wide element spacing? **High gain, less critical tuning and wider bandwidth**

Why is a Yagi antenna often used for radiocommunications on the 20-metre band? **It helps reduce interference from other stations off to the side or behind**

What does "antenna front-to-back ratio" mean in reference to a Yagi antenna? **The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction**

What is a good way to get maximum performance from a Yagi antenna? **Optimize the lengths and spacing of the elements**

If the forward gain of a six-element Yagi is about 10 dB, what would the gain of two of these antennas be if they were "stacked"? **13 dB**

# Wire Antennae

If you made a half-wavelength dipole antenna for 28.550 MHz, how long would it be? **5.08 metres (16.62 ft)**

What is the low angle radiation pattern of an ideal half-wavelength dipole HF antenna installed parallel to the earth? **It is a figure-eight, perpendicular to the antenna**

The impedances in ohms at the feed point of the dipole and folded dipole are, respectively: **73 and 300**

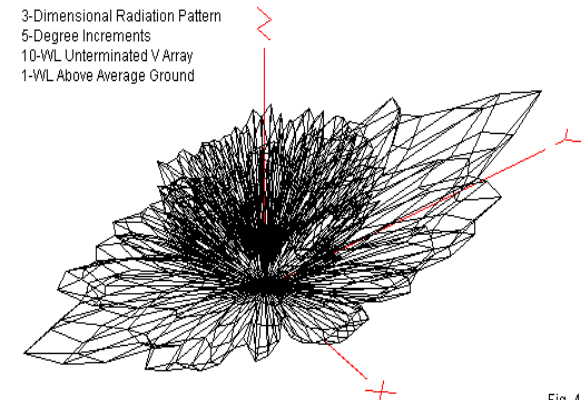
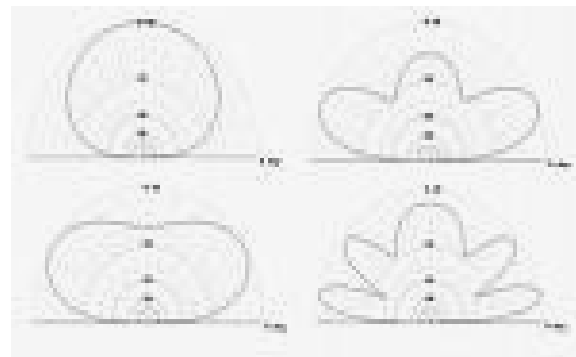
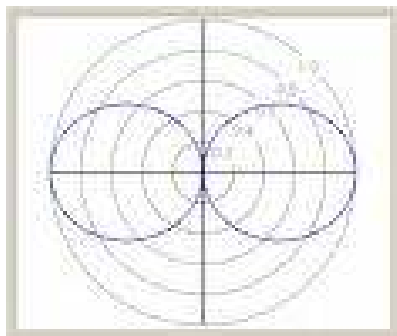


Fig. 4

# Wire Antennae

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A dipole transmitting antenna, placed so that the ends are pointing North/South, radiates: **mostly to the East and West**

How does the bandwidth of a folded dipole antenna compare with that of a simple dipole antenna? **It is greater**

What is a disadvantage of using an antenna equipped with traps? **It will radiate harmonics**

What is an advantage of using a trap antenna? **It may be used for multi-band operation**

What is one disadvantage of a random wire antenna? **You may experience RF feedback in your station**

# Quad / Loop antennae

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What is a cubical quad antenna? **Two or more parallel four- sided wire loops, each approximately one-electrical wavelength long**

What is a delta loop antenna? **A type of cubical quad antenna, except with triangular elements rather than square**

The cubical "quad" or "quad" antenna consists of two or more square loops of wire. The driven element has an approximate overall length of: **one wavelength**

The delta loop antenna consists of two or more triangular structures mounted on a boom. The overall length of the driven element is approximately: **one wavelength**

Approximately how long is each side of a cubical quad antenna driven element for 21.4 MHz?  
**3.54 metres (11.7 feet)**

Approximately how long is each side of a cubical quad antenna driven element for 14.3 MHz?  
**5.36 metres (17.6 feet)**

Approximately how long is each leg of a symmetrical delta loop antenna driven element for 28.7 MHz?  
**3.5 metres (11.5 feet)**

# Quad / Loops

Con't

Which statement about two- element delta loops and quad antennas is true? **They compare favorably with a three element Yagi**

Compared to a dipole antenna, what are the directional radiation characteristics of a cubical quad antenna? **The quad has more directivity in both horizontal and vertical planes**

Moving the feed point of a multi-element quad antenna from a side parallel to the ground to a side perpendicular to the ground will have what effect? **It will change the antenna polarization from horizontal to vertical**

What does the term "antenna front-to back ratio" mean in reference to a delta loop antenna? **The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction**

A Cubical Quad Antenna

